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VARIATION IN THE WOOD-MOUSE, *PEROMYSCUS LEUCOPUS*, FROM SEVERAL LOCALITIES IN NEW ENGLAND AND NOVA SCOTIA

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THIS report is a continuation of a previous paper by me (Dice, 1937) on variation in the wood-mouse, *Peromyscus leucopus.* Two of the stocks of wood-mice which are described in this paper come from islands off the New England coast. Three others are from widely separated localities on the New England mainland. The sixth stock is from the peninsula of Nova Scotia. Each of these stocks presumably is a sample of the wood-mouse population living at the place where the stock was secured. Taken together these six stocks cover much of the most northeasterly part of the range of the species.

Other variations in the wood-mouse than those here described are certainly present in parts of New England from which no stocks are at hand. Especially on the islands off the coast numerous local races with peculiar characters undoubtedly occur.

ACKNOWLEDGMENTS

The Kedgemakooge breeding stock was secured and donated by Carolyn Sheldon in 1933. Frank H. Clark secured the Muskeget Island stock in the summer of 1936. All of the other stocks were secured in the summer of 1931 by Philip F. Allan, while on an expedition supported by the William P. Harris, Jr., Research Fund of the Museum of Zoology, University of Michigan. Laboratory care for the live animals has been in part furnished by the Museum of Zoology. Measurements of some of the specimens were made by assistants employed through the National Youth Administration. Special thanks are due to Glover M. Allen for examining certain specimens

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METHODS OF STUDY

The mice described in this report are all laboratory-bred animals of the one-year age class. When killed for preparation as specimens none were less than 37 nor more than 78 weeks of age. The methods of rearing the animals, preparing the specimens, taking the measurements of body and skeleton, and making the tint photometer readings of pelage color are the same as those employed in my previous study of variation in the wood-mouse (Dice, 1937).

The external measurements of the mice were all made by myself. The measurements of the bones were made by Robert M. Bradley and Earl Cady, and the tint photometer readings by Brandt V. Hjelle, Jack D. Karp, and Merrel A. Taylor. The statistical calculations were made by Don Hayne, Margaret Liebe, Ray Moree, and Merrel A. Taylor.

Statistical comparisons between means have been made by the method developed by Leraas and myself (Dice and Leraas, 1936). Differences between two means which are greater than 2.7 or more times the standard error of their difference are with this method assumed to be statistically significant.

STOCKS OF MICE

The localities from which mice were obtained for this study are as follows:

Lake Kedgemakooge (Fairy Lake on most maps), Annapolis County, Nova Scotia.

West Lebanon, Grafton County, New Hampshire.

Greenland, Rockingham County, New Hampshire.

Dennisport, Barnstable County, Massachusetts.

The outer end of Monomoy Point, Barnstable County, Massachusetts.

Vineyard Haven, Island of Martha's Vineyard, Massachusetts.

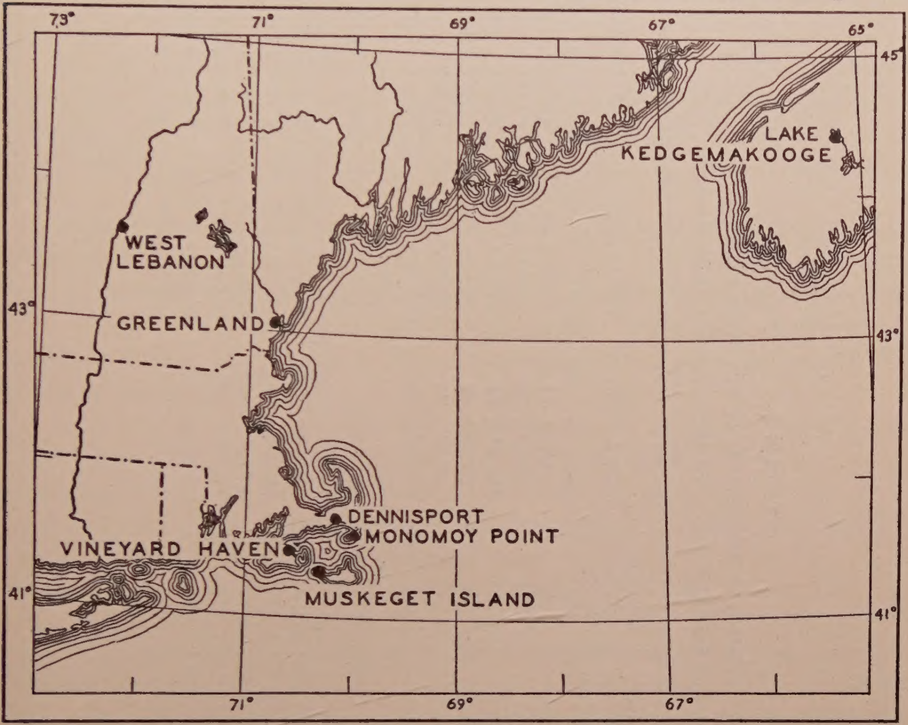
Muskeget Island, between Nantucket and Martha's Vineyard islands, Massachusetts. The mice of this stock were mostly infertile, and it was impossible to breed a sufficient number of offspring for statistical comparisons.

In the production of the laboratory-bred mice a slight amount of inbreeding occurred in the stocks from Lake Kedgemakooge and from Vineyard Haven; none of the other stocks were inbred in the laboratory.

In making the matings to produce the Monomoy stock a special effort was made to secure offspring with the *ammodytes* type of color. The one field-caught individual having ventral hair completely white to the base was mated with an individual in which the basal part of the ventral hairs was dilute gray instead of dark in color as in the other Monomoy field-caught animals. This selection of two of the parents possibly may have influenced, to some extent, the pelage color of the Monomoy stock. The matings in all other stocks were made at random, except that inbreeding was avoided so far as possible.

VARIATION IN BODY DIMENSIONS

The body length of the Vineyard Haven stock is significantly greater than that of any other of these stocks of *Peromyscus leucopus* except the one from Lake Kedgemakooge (Table I). In its turn the Lake Kedgemakooge stock has a significantly higher mean than any other except the Vineyard Haven and West Lebanon stocks. The West Lebanon, Greenland, and Dennisport stocks do not differ significantly from one another in this measurement. The Monomoy stock has significantly the smallest mean body length of all.



MAP 1. Localities in New England and Nova Scotia from which stocks of mice for this study were obtained.

Significantly longer tails are possessed by the Lake Kedgemakooge mice than by the mice of any other of these stocks. The mean difference from the Dennisport mice, which have the next longest tails, is nearly 4 mm. The Dennisport mice in their turn have significantly longer tails than have the Vineyard Haven mice, which are next in tail length. The Vineyard Haven, West Lebanon, and Greenland mice form a group intermediate in tail

TABLE I

Variation in Dimensions of the Wood-mouse

Means and Standard Errors of Measurements, in Millimeters

Stock	No. Speci-mens	Average Age Weeks	Body Length	Tail Length	Foot Length	Ear Length
Kedgemakooge, N. S.	26	56	102.81 ± .74	88.68 ± .92	21.681 ± .125	17.712 ± .163
West Lebanon, N. H.	43	55	100.53 ± .55	80.45 ± .82	20.960 ± .091	16.909 ± .118
Greenland, N. H.	88	56	100.01 ± .34	79.73 ± .55	20.831 ± .058	17.439 ± .091
Dennisport, Mass.	36	57	98.53 ± .51	84.94 ± .68	20.305 ± .081	16.831 ± .118
Monomoy Pt., Mass.	61	55	95.83 ± .43	76.89 ± .71	20.263 ± .076	16.366 ± .100
Vineyard Haven, Mass.	63	57	103.67 ± .68	82.33 ± .47	22.197 ± .075	17.297 ± .064
Stock	Femur		Mandible	Condyle-Premaxilla	Condyle-Zygoma	Bullar Width
Kedgemakooge, N. S.	17.344 ± .122		16.676 ± .127	25.656 ± .126	18.532 ± .080	10.972 ± .058
West Lebanon, N. H.	16.519 ± .097		16.756 ± .051	25.505 ± .083	18.407 ± .063	10.989 ± .038
Greenland, N. H.	16.860 ± .071		16.723 ± .043	25.045 ± .060	18.152 ± .044	11.022 ± .085
Dennisport, Mass.	16.703 ± .117		16.526 ± .069	25.040 ± .117	18.160 ± .084	11.063 ± .054
Monomoy Pt., Mass.	16.144 ± .085		15.961 ± .059	24.296 ± .076	17.420 ± .054	10.738 ± .029
Vineyard Haven, Mass.	17.782 ± .090		17.722 ± .050	26.255 ± .090	19.011 ± .074	11.395 ± .027

length. Of these, the Vineyard Haven mice have significantly longer tails than have the Greenland mice. The Monomoy mice have significantly shorter tails than have any of the other stocks.

In hind foot length the Vineyard Haven mice are significantly larger than any other of these stocks. The Lake Kedgemakooge stock, which is next to the largest in foot size, significantly exceeds all the stocks except that from Vineyard Haven. The West Lebanon and Greenland stocks do not differ significantly from one another in foot size, but both significantly exceed the Dennisport and Monomoy stocks.

The ears of the Lake Kedgemakooge, Greenland, and Vineyard Haven stocks are the largest of all. These stocks all significantly exceed the West Lebanon and Dennisport stocks, which are intermediate in ear size. The Monomoy mice have significantly smaller ears than the mice of any other stock.

The femurs of the Vineyard Haven stock are significantly longer than those of the Lake Kedgemakooge stock, which are next largest. The Lake Kedgemakooge stock in its turn significantly exceeds in femur length the Greenland, Dennisport, and West Lebanon stocks, which do not differ significantly from one another. The Monomoy mice have significantly the shortest femurs of all.

In length of mandible the Vineyard Haven significantly exceeds any other stock, and the Monomoy stock is significantly shorter than any other. The other stocks do not differ significantly from one another.

The skull length, from condyle to the front of the premaxilla, is significantly greater in the Vineyard Haven stock than it is in any other. The Lake Kedgemakooge and West Lebanon stocks, which are next smallest in skull length, both significantly exceed the Greenland and Dennisport stocks. The Monomoy mice are significantly the shortest of all in this measurement.

The measurement from the occipital condyle to the anterior edge of the zygomatic process of the maxilla is significantly greatest in the Vineyard Haven stock. The Monomoy stock is significantly the smallest of all in this measurement. The other stocks form an intermediate, somewhat graded, group, with the Lake Kedgemakooge stock significantly larger than the Dennisport stock; both the Lake Kedgemakooge and West Lebanon stocks are significantly larger than the Greenland stock.

The bullar width of skull is significantly greater in the Vineyard Haven stock than in any of the others, and the Monomoy stock is significantly the smallest of all. The other stocks form an intermediate group, no one of which differs significantly from any other.

VARIATION IN PELAGE COLOR

It has already been noted that in selecting the parents for the Monomoy stock an animal with the ventral hairs white to their bases was mated with one having the ventral hairs pale in color at their bases, rather than the usual dark color. This selection of parents may have somewhat increased the paleness of color of the laboratory-bred stock, for it is shown in a later section that mice which have completely white ventral hairs also average paler than normal on the upper parts of their body. It is doubtful, however, if the mean tint photometer readings of pelage color for the Monomoy stock have been appreciably increased by this selection.

The palest color tone of the dorsal stripe is shown by the stocks from Greenland, Monomoy, and West Lebanon (Table II). These have the highest tint photometer readings of all the stocks, and their means do not differ significantly from one another for any color screen. The stocks from Lake Kedgemakooge, Vineyard Haven, and Dennisport have the lowest tint photometer readings, and their means do not differ significantly from one another, except that for blue-violet the Lake Kedgemakooge mean is significantly higher than the means of the Vineyard Haven or Dennisport stocks and does not differ significantly from those of any of the other three stocks. For red the group of three palest stocks all have significantly higher tint photometer readings than have the three darkest stocks. For the other color screens, however, the pale and dark groups of stocks do not differ significantly in tint photometer readings.

TABLE II

Variation in Pelage Color of the Wood-mouse

Means and Standard Errors of Tint Photometer Readings, in Per Cent

DORSAL STRIPE

Stock	Red	Yellow	Green	Peacock Blue	Blue-violet
Kedgemakooge	7.54 ± .34	6.46 ± .30	5.54 ± .22	4.58 ± .21	4.00 ± .05
West Lebanon	9.26 ± .30	7.42 ± .23	6.10 ± .19	5.06 ± .18	4.32 ± .15
Greenland	8.65 ± .10	7.44 ± .08	6.36 ± .08	5.35 ± .06	4.70 ± .06
Dennisport	7.69 ± .17	6.23 ± .12	5.14 ± .12	4.31 ± .11	3.57 ± .09
Monomoy Point	9.08 ± .28	7.51 ± .23	6.23 ± .20	4.97 ± .14	4.38 ± .13
Vineyard Haven	8.03 ± .19	6.67 ± .16	5.27 ± .11	4.29 ± .09	3.59 ± .09

SIDE

Stock	Red	Yellow	Green	Peacock Blue	Blue-violet
Kedgemakooge	16.85 ± .50	14.23 ± .40	11.92 ± .30	9.27 ± .26	8.35 ± .25
West Lebanon	19.48 ± .33	16.35 ± .26	12.74 ± .24	10.10 ± .20	8.90 ± .20
Greenland	20.68 ± .16	17.00 ± .15	13.87 ± .14	10.70 ± .10	9.56 ± .09
Dennisport	18.09 ± .31	14.74 ± .25	11.66 ± .19	9.09 ± .17	7.80 ± .16
Monomoy Point	18.85 ± .36	15.44 ± .34	12.05 ± .28	9.39 ± .24	8.28 ± .21
Vineyard Haven	17.48 ± .30	13.92 ± .24	10.59 ± .16	8.02 ± .14	6.68 ± .13

The tone of color on the side of the body is palest in the Greenland mice, which have significantly higher tint photometer readings than any other stock for all color screens except yellow, where the difference from the West Lebanon stock is not significant. The stocks from West Lebanon, Monomoy, Dennisport, and Lake Kedgemakooge form a group intermediate in side color. The West Lebanon mice have, however, significantly higher tint photometer readings than the Dennisport mice for every color screen. Also the West Lebanon mice have significantly higher means for red and for yellow than the Kedgemakooge mice, and the Monomoy mice have significantly higher means for red than the Kedgemakooge mice. The Vineyard Haven stock has significantly lower tint photometer readings for side color than any other stock for green, peacock blue, and blue-violet, and for red and yellow it does not differ significantly from the Dennisport and Kedgemakooge stocks, which together with the Vineyard Haven stock have the lowest readings.

THE *AMMODYTES* TYPE OF COLORATION

The hairs of the underside of the body in the mice of the species *Peromyscus leucopus* usually are blackish in color over most of their length, but are provided with white tips, so that the ventral parts of the animal appear white or whitish in color. In the *ammodytes* type of coloration, on the contrary, the ventral hairs are white over their whole length, and the white of the underside of the body is accordingly somewhat clearer in tone than it is in the *noveboracensis* type of coloration.

The character of completely white ventral hair is, in the Monomoy mice, not fully alternative to the occurrence of hair having a dark-colored basal portion, for a considerable number of the Monomoy specimens are intermediate in type, the basal portion of the hair being pale in color, but not white. Of the Monomoy specimens at hand, made up of field-caught and of laboratory-bred one-year old and two-year old mice, eight have completely white or nearly white hair on the ventral parts of the body, thirteen are intermediate in type, and seventy-four have dark-colored bases to the ventral hairs.

A further variation of pelage color in the Monomoy mice consists of a lengthening of the white tips to the hairs on the ventral parts of the body. Many of the mice of this stock which have dark-colored bases to the ventral hairs show a lengthening of the white tips of these hairs. Of seventy-four specimens with dark-colored bases to the ventral hairs twenty-eight have lengthened white tips, whereas forty-six have the white tips of the normal length for the subspecies *noveboracensis*. On all the specimens which are intermediate in type the white tips to the ventral hairs are apparently longer than is normal for *noveboracensis*.

Slightly paler pelage color than normal on the upper parts of the body seems to be correlated in the Monomoy mice with the possession of completely white ventral fur. For the one-year age class there are available tint photometer readings of seven mice with all white or nearly all white ventral hairs, of ten mice with ventral hairs intermediate in type, and of forty-four mice with dark-colored bases to the ventral hairs. The mean readings for red on the dorsal stripe are 11.00 units for the mice with completely white ventral hairs, 9.50 for the intermediate mice, and 8.68 for the mice with dark-colored bases to the ventral hairs. The corresponding averages for the readings of red reflected from the side of the body are, respectively, 21.86, 19.20, and 18.30 units. None of the specimens of the Monomoy stock taken by Allan (in press) in 1931, however, represent the extreme development of the *ammodytes* type. Even our palest colored specimen is not much paler on the upper parts of the body than is the average of *noveboracensis,* and it would be impossible from the shade of color on the upper parts alone to distinguish these pale-colored Monomoy mice from the mainland specimens.

The mode of inheritance of the *ammodytes* type of coloration cannot be determined precisely from the data at hand. A female with completely white underfur mated to a male of intermediate type produced three offspring of the *ammodytes* type, three of the intermediate type, and five of the *noveboracensis* type. A female of the *noveboracensis* type mated to a male of intermediate type produced four offspring of the *ammodytes* type, five of intermediate type, and thirteen of the *noveboracensis* type. The female here was possibly heterozygous for the *ammodytes* type of coloration. Two different pairs of Monomoy stock, all of *noveboracensis* type, produced four and six offspring, respectively, all of the same type as their parents.

The indication from these figures is that more than one pair of hereditary factors is involved in producing the differences between the *ammodytes* and the *noveboracensis* types of coloration. It is further probable, but not proved by these data, that some or all of the *ammodytes* factors are either recessive or without dominance.

TAXONOMIC RELATIONSHIPS

The wood-mice from the island of Martha's Vineyard differ from the mainland mice in several characters, and they are assigned to the subspecies *Peromyscus leucopus fusus* Bangs. The desirability of recognizing *fusus* as a distinct subspecies is supported by the measurements of the Vineyard Haven stock. In body length this stock has the largest mean of all the six stocks here described, though the difference from the mean of the Kedgemakooge stock is not statistically significant. In foot length, in length of femur, and in every skull measurement the Vineyard Haven stock significantly exceeds all of the other stocks. In ear length it does not differ significantly from the stock having the largest ears. In tail length, on the contrary, it is intermediate among the stocks. In proportion to the body size the tails of the mice of the Vineyard Haven stock are, therefore, moderately short.

The rostrum and nasal region of the Vineyard Haven skulls appear to be heavier than in *noveboracensis* from the mainland of New England, agreeing with the diagnosis of *fusus* by Osgood (1909: 122). The auditory bullae are larger than in *noveboracensis*, and in the Vineyard Haven stock are not "rather small." I have, however, not made any critical measurements of either of these characters.

In pelage color the Vineyard Haven stock ranks among the darkest colored of the six stocks here described from New England and Nova Scotia. The tint photometer readings of the Vineyard Haven mice are not significantly higher than are those of the mice of any other of these stocks, either on the dorsal stripe or on the side of the body. For the side of the body the Vineyard Haven means are, for the color screens green, peacock blue, and blue-violet, significantly lower than are the means of any other of these six stocks.

Compared to the stocks of *noveboracensis* previously described from the northeastern United States (Dice, 1937: 8, 11) the stock of *fusus* from Vineyard Haven is significantly larger than is any other stock in body length, length of hind foot, skull length, bullar width, and perhaps in several other of the measurements. In pelage color the Vineyard Haven stock ranks among the darker colored of the stocks, though several stocks of *noveboracensis* from the interior states have significantly lower tint photometer readings, both for the dorsal stripe and for the side of the body.

The wood-mice of Monomoy Island were considered by Bangs (1905: 14–15) to represent a pale-colored subspecies, *Peromyscus leucopus ammodytes,* which, moreover, has the hairs of the undersurface pure white to their bases. Bangs stated that of the mice taken on the island a few were indistinguishable from normal mainland *noveboracensis,* and that a considerable number were intermediate between typical *ammodytes* and *noveboracensis.* The reason for the great variability in pelage color in this population was believed by Bangs to be due to occasional invasions of *noveboracensis* stock made possible by the periodic existence of a connecting beach between the mainland and the island.

Of the specimens from Monomoy Island available to Osgood (1909: 121–22) thirteen were considered to be typical *ammodytes* and twelve intermediate toward *noveboracensis.* Osgood failed to find any difference in size, body proportions, or skull characters distinguishing *ammodytes.*

In the summer of 1931 Monomoy "Island" was found by Philip Allan (in press) to be connected to the mainland by a wide neck of sand. Monomoy Point at the present time is, therefore, a peninsula. Furthermore, Allan found that the mice were rather scarce, whereas Bangs and Miller had found them "in the greatest abundance" in 1893.

Most of the wood-mice collected by Allan near the end of Monomoy Point are of the *noveboracensis* type. It is impossible to state the proportional number of this type collected, because the field-caught animals were not marked for some months after they had been brought to the laboratory, and during this time several of the females had given birth to litters which had grown to adult appearance.

The laboratory-bred mice of the Monomoy stock are on the average not exceptionally pale in pelage color, notwithstanding the slight preference for animals with white ventral underfur employed in the selection of the parents of the stock. In tint photometer readings of the dorsal stripe they rank with and do not differ significantly from the West Lebanon or Greenland stocks of undoubted *noveboracensis.* In readings of the side they are significantly exceeded for every color screen by the Greenland stock; they do not differ significantly for any color screen from either the West Lebanon or Dennisport stocks; and in comparison with the Lake Kedgemakooge stock they have a significantly higher reading only for red.

The possession of completely white underparts by a portion of the wood-mice on Monomoy ''Island'' seems hardly of sufficient importance to justify the recognition of the mice of this locality as a separate subspecies, and I agree with Allan (in press) in considering *ammodytes* a synonym of *noveboracensis.*

My specimens from Muskeget Island are rather robust in size, agreeing with the observations of Bangs (1905: 12) and of Osgood (1909: 122) on the mice of this island. Not a sufficient number of measurements of mice of comparable age are, however, available for statistical treatment.

The basal portions of the ventral hairs of all our ten specimens of Muskeget Island mice are pale in color, the shade being similar to that of some of the intermediate specimens from Monomoy Point.

The white tips of the ventral hairs are long in all the specimens from Muskeget Island, as they are in many of the specimens from Monomoy Point. However, the length of the white tips to these hairs is somewhat variable in the wood-mouse, and may be in part a seasonal character.

None of the Muskeget Island specimens have the ventral hairs completely white to their bases as do some of the Monomoy mice. All mice of the species *Peromyscus leucopus* seem to have the hairs of the chin, of most of the throat, and of a small area in the inguinal region white to their bases. The size of these white areas varies considerably in all the stocks. Some individuals have a small completely white pectoral spot, some have a narrow white line in the middle of the lower abdomen, and some have the insides of the thighs completely white. The Muskeget Island mice, however, do not seem to have these white spots larger in area than they are on the mice of stocks assumed to be normal *noveboracensis.* Glover M. Allen has kindly examined for me the seventeen specimens from Muskeget Island in the Museum of Comparative Zoology, and he has found no specimen with all the ventral hairs completely white.

The pale-colored bases of the ventral hairs of the Muskeget Island mice might be assumed by some persons to be of sufficient importance, when associated with the robust proportions of these animals, to justify their recognition as a separate subspecies. It must be remembered, however, that many of the Monomoy mice also have pale-colored basal portions to the ventral hairs, although these mice are in general rather small in body size. The Muskeget Island mice are, therefore, assigned to *noveboracensis,* notwithstanding the fact that they are not fully typical of that subspecies.

All the stocks of wood-mice from the mainland of New England are referable without question to *noveboracensis,* even though there are considerable variations in body proportions and also in pelage color between the several stocks.

Compared to the other stocks of the wood-mouse previously described (Dice, 1937) from stations farther west and south in the United States, the New England mainland stocks have a tendency to be rather large in most dimensions. For no measurement, however, does any New England mainland stock significantly exceed every one of the stocks of *noveboracensis* previously described from the interior of the United States.

For *noveboracensis* the Lake Kedgemakooge, Nova Scotia, wood-mice are exceptionally large in body length, tail length, hind foot length, and ear length. The Lake Kedgemakooge mice have significantly longer bodies than have the mice of any other described stock, except those of the West Lebanon, New Hampshire, stock, which they exceed only by 2.28 ± 0.93 mm. The Lake Kedgemakooge stock exceeds the Merom, Indiana, stock, which has the longest body of the stocks previously described from the interior United States, by 3.11 ± 1.08 mm., a significant difference.

The exceptionally long tails of some specimens of wood-mice from Nova Scotia have already been noted by Osgood (1909: 119). The mice of the Dennisport, Massachusetts, stock have the longest tails of any of the New England stocks, and they are exceeded by the Lake Kedgemakooge mice by an average of nearly 4 mm. The Cambridge, Maryland, stock, which has the shortest tails yet reported for any one-year old *noveboracensis* (Dice, 1937: 8) averages 16.87 mm. shorter in this measurement than does the Lake Kedgemakooge stock. The Marshall, Missouri, stock of wood-mice, however, had tails which averaged only 2.11 ± 1.12 mm. less than did the Lake Kedgemakooge stock; this is not a statistically significant difference.

In length of hind foot the Lake Kedgemakooge stock significantly exceeds every other described stock except the one from Greenland, New Hampshire. Likewise, in ear length the Lake Kedgemakooge stock significantly exceeds every other stock except the one from Moville, Iowa, which is only 0.373 ± 0.166 mm. shorter. In the measurements of femur and skull the Lake Kedgemakooge mice, while relatively large, average smaller than certain of the stocks from farther west.

The tint photometer readings of pelage color of the New England and Nova Scotia stocks, both for the dorsal stripe and for the side of the body, all fall within the range of variation of the stocks of wood-mice previously described from the interior United States.

The attenuation of the body, tail, feet, and ears of the Nova Scotia wood-mice may be considered perhaps to be the extreme development of the *noveboracensis* type. An attenuation of lesser degree characterizes the New England mainland stocks. Notwithstanding the great length of body in these New England and Nova Scotia wood-mice the skulls are not exceptionally long or heavy.

DISCUSSION

A considerable amount of local variability is present in the wood-mice here described from New England and Nova Scotia. The mice of no two localities are quite alike either in average body dimensions or in the average tint photometer readings of pelage color. Local variability of a similar kind occurs in all the species and races of *Peromyscus* which have been critically studied.

On the Island of Martha's Vineyard the wood-mice are large in body size, and the rostrum and nasal region of the skull are especially heavy. The mice on this island, therefore, have been assigned to the distinct subspecies *fusus.* The reason for the large size of the mice of this isolated island is not known.

The New England mainland stocks of *noveboracensis* tend in general to be rather larger in most body dimensions than the stocks from localities farther west and south. The Nova Scotia mice develop extremely long bodies and long body members, but the animals are not exceptionally robust. No explanation is at hand for this trend toward attenuation of body, tail, ear, and hind foot in these stocks from the most northeasterly part of the range of the species.

A few of the wood-mice living on the sandy soil of Monomoy Point, Massachusetts, have the *ammodytes* type of coloration, in which the hairs of the underside of the body are completely white to their bases and the color of the pelage on the upperside of the body is somewhat paler than usual for the subspecies *noveboracensis.* In most of the Monomoy wood-mice, however, the ventral hairs have blackish bases, as is usual for *noveboracensis.* The individuals thus characterized do not average paler on their upper surfaces than the mice of the same species living elsewhere on the New England mainland.

Some intermediates between the *ammodytes* and *noveboracensis* types of coloration also occur on Monomoy Point. These intermediates have the bases of the ventral hairs a dilute shade of gray, the white tips of the ventral hairs are conspicuously long, and the shade of color of the upperside of the body is very slightly paler than usual for *noveboracensis.*

The wood-mice from Muskeget Island have the basal part of the ventral hairs paler than normal for *noveboracensis,* and thus resemble for this character the Monomoy intermediates between the *ammodytes* and *noveboracensis* types of coloration. None of the available specimens from Muskeget Island, however, have all the ventral hairs completely white, as does typical *ammodytes*. There are too few laboratory-bred mice from Muskeget Island available to make a statistical study of their pelage color, but so far as can be determined by superficial examination they are not paler on the dorsal surface than are the wood-mice of the New England mainland.

The soil of Muskeget Island is presumably very similar to the soil of Monomoy Point. According to F. H. Clark, who collected our stock on Muskeget Island, the soil there is composed entirely of rather coarse sand which is pale in color. Some humus has accumulated in spots where there is a heavy growth of vegetation.

The pale colors of the basal parts of the ventral hairs of the Muskeget Island mice possibly are produced by hereditary factors which differ from those producing the pale colors of the Monomoy mice. The two places, although not very far apart geographically, must have been separated for a long period of time by a width of ocean practically impassible for wood-mice. Even if the pale colors exhibited by some of the mice in these two situations are due to the same hereditary factors, the parallel survival and the increase of pale-colored animals in the two separated places still needs explanation.

The similarity in color tone of the ventral underfur of the Muskeget Island mice and of some of the mice on Monomoy Point is certainly not due to any direct effect on the individual animals from the similar environment at the two places, for the same characters occur in the laboratory-bred mice as occur in the field-caught animals.

The pale colors of some of the Monomoy Island mice were assumed by Bangs (1905: 12 and 14) to have developed to afford concealment on the pale-colored sand of this locality, where hardly any trees occur. The pale color of the dorsal surface of the Monomoy wood-mouse, which has been emphasized by Bangs as being characteristic of the extreme development of the *ammodytes* type of color, would be expected to be more concealing on the pale-colored Monomoy sands than would the normal *noveboracensis* color, and theoretically, therefore, would tend to be selected.

It is difficult to imagine, on the other hand, that the pale-colored bases of the ventral hairs of some of the wood-mice living on these New England sand islands can have any important survival value. The basal portions of the ventral hairs are in these mice effectually concealed by the white tips to the hairs. Furthermore, the underside of the body would not in any ordinary position of the animal be visible to predaceous birds flying above, nor even to predators approaching from the side. On Muskeget Island birds are probably the most important predators, but on Monomoy Point some predaceous mammals also occur (Allan, in press).

A possible explanation for the white bases of the ventral hairs of the Monomoy mice may be found in the previously described correlation between the colors of the ventral and dorsal parts of these animals. There is a tendency for those Monomoy mice which have the upper parts of the body relatively pale in color also to have the ventral hairs completely white. Perhaps the dilution in pelage color on both the upper and lower surfaces of the *ammodytes*-type mice may be due to the same hereditary factor or factors. If this be true, natural selection of mice with pale dorsal colors would indirectly produce mice with pale ventral colors.

This explanation will not, however, account for the dilution in color of the ventral underfur of the Muskeget Island mice, for these animals are not, so far as is known, paler in color on their dorsal surfaces than are normal *noveboracensis* from the New England mainland.

Nevertheless, the occurrence in the wood-mice living on the two separated sandy situations, Monomoy Point and Muskeget Island, of a somewhat similar color variation suggests that the environment is in both situations exercising some sort of directive control of pelage color.

If Monomoy Island had remained isolated from the Massachusetts mainland it is quite probable that a distinct local race of wood-mouse characterized by the *ammodytes* type of pale coloration would in time have become established there. The type specimen of *ammodytes* was collected by Miller and Bangs in 1893 and at that time Monomoy Island was completely separated from the Massachusetts mainland. Some time since 1916 the island has become connected to the mainland by a neck of sand (Allan, in press).

Some of the specimens collected by Bangs while the island was still connected with the mainland are much paler than any of those which were obtained in 1931 by Allan (in press). Even when Bangs collected on the island, however, only a part of the wood-mice living there were of the *ammodytes* type, and a considerable number were indistinguishable from *noveboracensis.* With the present lack of isolation of the wood-mice on Monomoy Point the *ammodytes* type of coloration is being swamped, according to Allan, by interbreeding with the mainland *noveboracensis.*

The swamping of the *ammodytes* type of coloration which seems to be taking place on Monomoy Point must be actually an interchange of hereditary factors between the mice of the peninsula and those of the mainland. The *ammodytes* heredity undoubtedly has spread into the mice of the mainland at the same time that the *noveboracensis* heredity has spread into the mice on Monomoy Point. Unless there is some selection for one or the other type of coloration the proportional number of genes of each should, in a large population, remain approximately the same in each succeeding generation (Dobzhansky, 1937: 132). In the combined populations of wood-mice from the former Monomoy Island and from the mainland the number of *ammodytes* genes is, of course, much less than the number of *noveboracensis* genes. If we assume the *ammodytes* genes to be mostly recessive they would now be carried almost entirely in the heterozygous condition. The *ammodytes* homozygous recessive, therefore, under present conditions would be expected to appear in nature only infrequently.

If the hereditary factors producing the *ammodytes* type of coloration, instead of being recessive, are multiple factors without dominance, as they possibly are, the effect of interbreeding with the large *noveboracensis* mainland population will also result theoretically in the diffusion of the *ammodytes* factors throughout the whole combined population. In this case each of the *ammodytes* factors, when it occurs in heterozygous condition, would be expected to dilute slightly the pelage color of the individual mouse concerned. An *ammodytes* factor occurring in homozygous condition should produce a still paler tone of pelage color. The main difference here between recessive factors and those without dominance is that the heterozygotes of the factors without dominance should produce a slight effect on pelage color which may be of importance in natural selection, whereas theoretically only the homozygous recessives have any value for selection.

The considerable variability in measurable hereditary characters exhibited by all populations of *Peromyscus* which have so far been studied is probably due in part to the occasional absorption into the population of local races which for a longer or shorter time have been partially or completely isolated. Isolated local populations seem particularly likely to develop peculiar characters. For instance, on a sand-spit off the coast of California near Eureka the deer-mouse (*Peromyscus maniculatus rubidus*) has developed a peculiar pale-colored local race (Sumner, 1917: 174–80). Monomoy Point is another example of such a local center of origin. From such local centers the peculiar hereditary characters tend to spread out, increasing the variability of the whole species.

SUMMARY

The wood-mice (*Peromyscus leucopus*) on the island of Martha's Vineyard, Massachusetts, are large in body size and have heavy skulls. They are assigned to the subspecies *fusus*.

On the New England mainland and especially in Nova Scotia the wood-mouse (subspecies *noveboracensis*) shows a trend toward elongation of the body, tail, ear, and hind foot, but the animals are not particularly robust.

Formerly, a considerable proportion of the wood-mice living on Monomoy Island exhibited the *ammodytes* type of coloration, which is characterized by pale dorsal colors and pure white ventral hairs. Now that the island is connected with the mainland the *ammodytes* type of coloration is in process of being swamped by the *noveboracensis* type.

On Muskeget Island the basal parts of the ventral hairs of the wood-mice are considerably paler than normal for *noveboracensis*, and in color they resemble the corresponding hairs of some of the mice of intermediate *ammodytes* type from Monomoy Point.

The considerable variability in hereditary characters exhibited by all populations of *Peromyscus* is probably due in part to the occasional absorption into the species of local races, such as that on Monomoy Island, which have been partially or completely isolated.

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